REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	22 Nov 1999	Final Report

4. TITLE AND SUBTITLE

Atmospheric Seeing Conditions at Mt. Maidanak, Phase 1

5. FUNDING NUMBERS

F61775-98-WE104

6. AUTHOR(S)

Professor Valeri S. Shevchenko

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Science Research Institute of Precision Device Engineeriidanak
Aviamotornaya Ulitca 53
Moscow 111250
Russia

8. PERFORMING ORGANIZATION REPORT NUMBER

N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

EOARD
PSC 802 BOX 14
FPO 09499-0200

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

SPC 98-4059

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

A

13. ABSTRACT (Maximum 200 words)

This report results from a contract tasking Science Research Institute of Precision Device Engineeriidanak as follows: The contractor will investigate and analyze atmospheric seeing data recently collected at Mt. Maidanak, and compile engineering drawings of the 110 cm telescope for possible future use in mounting sensors and other equipment.

14. SUBJECT TERMS

EOARD, Beam Propagation, Imaging, Optical Diagnostics, Turbulence Modeling, Atmospheric Propagation, laser atmospheric propagation, Atmospheric Science

15. NUMBER OF PAGES

25

16. PRICE CODE

N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19, SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102

FINAL REPORT

THE MAIN RESULTS of RESEARCHES of ATMOSPHERIC OPTICS PARAMETERS ON MAIDANAK MOUNTAIN 1969 - 1999.

Contract F61775-98-WE104 Shevchenko V.S. SPC 98 - 4059

Astronomical Institute of Academy of Science of Uzbekistan Republic.

abstract.
The review of results of researches of parameters of atmospheric optics inMt. Maidanak observatory from 1969 to 1999 year by different methods and authors is given. All measurements of quality of the image, including Szrazin's DIMM by the device, with which was studied Paranal Peak for nwe ESO in Chile, confirm excellent quality of the atmospheric images . The average corner of the atmospheric optics resolution t (= 0. (6 - 0.7. The illustrations of the images of space objects obtained at Mt. Maidanak with the high resolution are resulted.

I.INTRODUCTION

In August, 1969, after performance of the 8-year's forwarding program of search of places for astronomical observatory in Central Asia former USSR, first were carried out optical and micro gradient measurement of atmospheric optic parameters on the Maidanak mountain (φ=38° 41' 05"; λ= 66° 56' 38" east longitudes, h = 2750 m) Shevchenko, 1972). In 1970 y. the first results of these measurements were published (Slutckii and Princev, 1970). As the results surpassed the data of all previous forwarding researches in Central Asia, in 1970 y. on the Maidanak mountain the complex expedition equipped advanced the then with the optical equipment and the equipment for research of physics of an atmosphere was organized. The analysis of results of researches of parameters of atmospheric optics on the Maidanak mountain , carried out with this equipment in 1970-1971yy. has confirmed and has specified these parameters, having shown, that they are in certain respects unique, surpassing all known before that time in territory former USSR and compete to the best astroitems and observatories of the world (Shevchenko, 1973). Further on the Maidanak mountainand at the next tops were constructed astronomical observatories. Numerous researches of atmospheric optic parameters of proceeded until recently (Illiasov et al.., 1999), including with application of the equipment developed by Sarazin (Sarazin et al., 1990) for a choice of a place new Southern European observatory (Paranal Peak), and also with application of the special equipment on telescopes by a diameter up to 1.5 m. Excellent average and minimal means of parameters of optical nonstability on the Maidanak mountain, has allowed in a number{ of researches to obtained unique results comparable on the angular sanction with the images that obtained by space telescopes.. The purpose of the given work is the comparison and summarizing of researches of parameters of atmospheric optics on the Maidanak mountain.

II.THE ASTROKLIMATE PARAMETERS, EFFICIENCY COEFFICIENT .

There are four rather independent parameters of astronomical climate, that have direct influence on the quality and limiting parameters of information obtained by ground optical equipment.

Effectiveness astroclimate coefficient for the given place

Effectiveness astroclimate coefficient for the given place for the given telescope with the resolution r ", working in a range of lengths of waves $\Delta\lambda$ (Shevchenko,1973).

A = TPFR,

Where first three factors:

T - there is an effectiveness ratio of clear time in comparison with ideal item on equator, where losses on twilight least, and the clear time without astronomical twilight makes 100 % or 3466 hours (T=1),

$P = \int p\lambda d\lambda$ there is a factor of a transparency of an atmosphere in a range of working lengths of waves $\Delta\lambda$ for the given telescope

$F = \frac{Fo}{Fo + Fd}$ Factor of light pollution of the night sky Fo by artificial illumination Fd

AQ F00-03-0688

In a range of working lengths of waves $\Delta\lambda$,

Do not depend on the resolution of a telescope, and factor of the resolution of atmospheric optics depends on the resolution of a telescope, installed in the given place

$$R = \frac{r''}{\sqrt{r2 + t2}}$$

Where t" - there is a factor of the atmospheric optics resolution for a telescope by a diameter d and r" resolution.

As a rule for good places factor T varies from 0.5 up to 0.9,

Factor of a transparency in optical and near IR -spectral region P = 0.8 - 0.92

Factor of a background F in absence of light pollution is close to 1, but near to large cities can be essentially smaller. For example, for Mt. Palomar F = 0.6 by our ratings.

Only factor R can vary in very wide limits, depending on quality of the established telescope and quality of atmospheric optics t (. So for an adaptive telescope with the sanction r" =0.1 (on Maidanak R = 0.2 and for La Silla R = 0.15- 0.2. For the same telescope installed in SAO, R = 0.06.

- ***Amount of time for observations***

A part of the time during the year does not suit for optical and infrared (IR) measurements due to clouds. The exact registration of the time suitable for observation and intercomparison of sites for selection of the optimum region for astronomical climate studies are the first step for observatory site selection. Special requirements are applied to night observations with the maximum resolution and with the best signal/noise ratio: it is necessary to perform observations only from the end to the beginning of astronomical twilight with cloudless sky. Thanks to homogeneous information published at the end of 1960-s in the voluminous reference book "Reference book on the USSR climate" (Gidrometeoizdat), the large scale maps of the distribution of clear time on the USSR territory were developed. Maidanak mount is located in the region of absolute maximum of clear time on the FSU territory. According to the above described criteria, average annual number of clear and cloudless night hours is about 2000.

Approximately 60% of the night time is suitable for astronomical observations. The maximum of clear weather is determined by the stable Asian anticyclones and falls on July - August - September (22-30 clear nights), and the minimum - on March - April. The day clear time distributes the same way, when bright background of the sky can be overcome during laser ranging of ASB or during observations in the IR spectrum range. However, the percentage of the day cloudless observation time is close to 50%. This is defined by the fact that in addition to the global cloudiness, related to the coming and living of atmospheric fronts, in the mount regions and in particular near the Maidanak mount there quite often are processes of forming of the local convective cloudiness with the maximum in the daytime.

Monthly changes of the number of clear time are the higher, the lower is average monthly amount of clear hours. Maximum and minimum amounts of the average monthly clear time are given in the section 1.3 of the present report together with other astronomical parameters. Permanent statistics of the time suitable for observations on Maidanak mount is carried out since the April 1970, during last 25 years, using the same methods.

Average Monthly number of clear night hours minus astronomical twilight.

Since the April of 1970 registration of observation time was carried out by the expedition group, since 1976 - by the standard observatory means.

Table 1. Number of clear night hours without astronomical twilight

Month	Average	Minimum	Maximum	Forecast	Actual
January	132	94	204	130	134
February	124	88	168	125	116
March	120	105	202	120	118
April	114	72	148	115	118
May	130	110	175	130	132
June	145	128	157	145	148

July	190	174	198	190	186
August	226	205	242	220	224
September	264	228	272	260	254
October	162	122	196	170	178
November	156	88	184	150	162
December	140	111	202	140	144
Year	1903	1780	2040	1890	1954

We also used for analysis the results of many-year registration of the Expedition of the State Astronomy Institute named after Shternberg (SAI) and of the Astronomy Institute of the Lithuania Academy of Science. All the results show agreement within 2% In the last column of the table there is given actual average monthly time of observations according to the data of the

Astronomy Institute of Academy of Science of Uzbekistan about operation of photometric telescopes in the time period 1985-1992. Here observation partly use astronomical twilight.

Atmosphere Transparency Factor.

This parameter has a simple definition in the practical astrophysics, so it can be well applied for comparison of astronomical sites and estimation of astronomical climate efficiency for the given telescope.

With limitation of the spectrum range by the borders of wide photometrical bands UBVRI, the integral transparency factor for the Maidanak atmosphere is close to P=0.87 (Zheleznyakova, 1984). Measurements of the atmosphere transparency factor have been performed since 1970 by means of photoelectric photometers with classical methods described in Zheleznyakova's report (1984). Values of the atmosphere transparency factors in the period of stable clear weather are close to the transparency factors in the national observatory Kitt Peak and during winter and spring time they are comparable with the transparency of Chili's high-mount sites and are close to those of an ideal atmosphere with a low concentration of aerosols (See figure 1).

Berdnikov and Shevchenko (1989) performed an analysis of a few thousands of photoelectric measurements of atmosphere transparency on Maidanak mount and realized recurrence in the daily, weekly and annual changes of transparency. Measurement of atmospheric transparency in the IR part of spectrum cause some difficulties. Direct measurements of attenuation of IR flux by atmospheric molecular bands is bulky. Mass measurements during at least one year are necessary. We made limited measurements of water vapor bands in the near IR part of the spectrum "alpha" (0.72 m) and "z" (0.82 m) which were performed during 39 nights synchronously with aerology sounding of atmosphere at altitudes up to 12-16 km. Aerological data allow to calculate complete amount of water vapor containing in the vertical column of atmosphere at this moment. Methodology of measurements is described in the review of Zheleznyakova (1984). As a result of these measurements, a reliable calibration curve of atmosphere transmission in water bands in the near IR part of spectrum vs. complete contents of water vapor in the vertical column was obtained from the data of radiological sounding. This calibration curve is shown in fig. 2a. A histogram of average monthly distribution of the amount of precipitated water on Maidanak mount is shown in fig. 2b (Zheleznyakova, 1984). Season oscillations of the amount of precipitated water practically coincide with the season changes of the atmospheric transparency in all spectral range. Later Berdnikov and Shevchenko (1989) show that all changes in the atmospheric transparency on Maidanak are mainly defined by aerosol and

molecular components of the water vapor's absorption in atmosphere. Contribution of dust even in the summer time is noticeable only after strong dust storms in the near Western and Southern deserts.

Average data

We collected all data of measurements of atmospheric transparency on Maidanak mount between 1975 and 1995 in the wide photometry bands UBVRI, and also spectrophotometrical measurements of transparency. These data confirm first systematic results obtained by us on Maidanak mount in 1980-1981 (Zheleznyakova, 1984). Table 3 contains monthly and average season factors of atmospheric transparency in the UBVRI bands. Summer season and autumn - winter season are outstanding with transparency values.

Fig. 3 shows comparison of the season distribution of spectral transparency factor versus calculated transparency factor for the atmosphere at the level 2700 m with pure molecular attenuation. Fig. 4 shows results of measurements of atmosphere transparency factor after taking into account molecular dissipation.

Information about the transparency in the IR range was obtained only in the seasons 1980-1981 and are given above, in the section 1.1.

Table 2. Average transparency factors during the observatory operationtime.

Month, Season	U	B	V	R	I
April	0.575	0.345	0.220	0.115	0.140
May	0.570	0.321	0.200	0.11	0.14

Table 2 continue. Average transparency factors during the observatory operationtime.

Month, Season	U	B	V	R	I
June	0.572	0.341	0.225	0.154	0.141
July	0.592	0.360	0.235	0.156	0.148
August	0.575	0.352	0.215	0.145	0.120
Average per season	0.577	0.344	0.219	0.142	0.138
September	0.540	0.330	0.190	0.120	0.090
October	0.462	0.292	0.165	0.128	0.084
November	0.418	0.226	0.133	0.098	0.066
December	0.440	0.235	0.140	0.075	0.055
January	0.488	0.256	0.138	0.040	0.040
February	0.414	0.207	0.114	0.056	0.037
March	0.419	0.204	0.138	0.052	0.042
Average per season	0.440	0.237	0.138	0.074	0.054
Average per year	0.505	0.288	0.175	0.106	0.091

Light Contamination by the illumination of surrounding settlements.

It is not present on Maidanak. This is related to both Maidanak's remoteness from settlements and their small size. Rather complex methodology of the superficial background photometry of night sky which takes into account contribution of zodiacal light, star component and diffused galactic background and also geophysical night luminescence of the atmosphere was used for measurement of light contamination on Maidanak mount. The absence of light contamination was shown in a few measurement sessions.
The sample of atmosphere phone brightness measurement are given on figure 3 (Shevchenko,1984b).

III. THE ATMOSPHERE OPTICAL NONSTABILITY. IMAGE QUALITY.

The Elementary Model of Atmospheric Optical Nonstability Generation.

The successes achieved in a choice of optimum conditions for astrophysical supervision in Southern European La Silla observatory, Southern American Sierro Tollolo observatory and national Kitt Peak observatory, and also search of places for new observatories stimulated development of the theory of atmospheric optical nonstability.

Some results and hypotheses were formulated on the Roman symposium in 1963.

Already in the beginning 60 years the point of view about the primary contribution to optical atmospheric instability nearground of layers of air prevailed. In the nearground layer, both in night, and in day time, the tempera-

ture gradient is great. The temperature gradient is directly connected to change of factor of refraction of light beams in air. At hashing air in near ground layer there is a greatest number optical heterogeneity. A by a layer an atmosphere adiabatic (in physics of an adiabatic atmosphere is called « as a free atmosphere »). The moving of air on a vertical with small speeds does not conduct to creation optical heterogeneity , since in adiabatic atmosphere any element of air at moving quickly accepts temperature and density of environmental gas. Therefore in the beginning 60 years the idea of installation of large optical telescopes at the isolated tops in mountain areas prevailed. The high isolated mountain peaks towered above a near ground layer and the conditions at tops came nearer to conditions in a free atmosphere. And further, down to the present time, this idea is most fruitful.

On the Atmospheric Turbulention Theory.

At the same time, the described above simple circuit of occurrence optical heterogeneity in an atmosphere, frequently did not correspond to the validity. The optical instability, as have shown measurements, could arise and in high layers, where "a «free" atmosphere theoretically settled down.

Tatarsky (1967), using base of the Monin - Obuhov theory about movement of bodies in turbulention environment, has created the theory of atmospheric optical instability. This theory has received the name of the theory of distribution of waves in turbulention atmosphere and soon has received the European recognition. Till now researchers of atmospheric optical instability use « structural functions » Tatarsky (1967), describing atmospheric turbulention and continue to discuss the reasons of a deviation of the Kolmogorov- Obuhov law from "«normal".

Tatarsky (1967) assumed, that used between the turbulention characteristics and distortions of the optical images are fair in conditions locally homogeneous and isotropic turbulention, in which the Kolmogorov- Obuhov law , having in the assumption "«frozen" turbulention form of the law (function dependent on temperature and a parameter of refraction of light on heterogeneity) in a degree - 5/3 for spectral density of pulsations of temperature $W_T(f) \propto \wedge\text{-}5/3$, where (frequency in Hz is carried out).

It is necessary to note the basic problems of the theory of distribution of waves in turbulentionly atmosphere (Tatarsky, 1967):

1). The theory is based on an experimental material received extremely in the nearground layer of an atmosphere, where at the large speeds of a wind really arises turbulention. At the same time in night time at small speeds of a wind there is hashing bottom cold and top warmer layers of air, that creates optical layers with different factors of refraction. This phenomenon in physics of an atmosphere is connected to existence of a vertical component of a vector of speed of a wind and heterogeneity in a spreading surface and carries the name «advection», as against convection of hashing in day time time caused come to the surface of the warmer nearground layers of air.

2) In a situation of the minimal optical distortions, which most of all interests the astronomers, the atmosphere, strictly speaking, is not turbulention . If to address to physics of continuous environments (Feinman et al.., 1966), we shall be convinced, that turbulention and the whirlwinds, accompanying it, arise at movement of environment concerning an obstacle, when the numbers Raynolds exceed 10-20. At small speeds of a wind the Raynolds number is less 10, and the conditions for formation of whirlwinds and turbulention basically are absent. Dissipation of energy in a real atmosphere is absent at small speeds of a wind, since practically is absent " turbulention ".

The entry conditions « locally homogeneous and isotropic » turbulention can not be distributed on free (adiabatic) atmosphere, hence in case of good optical properties of an atmosphere the integration on a beam of sight of functional turbulention parameters and application of a condition «frozen» turbulention is incorrect also.

In result there is a paradoxical situation, in which « the law -5/3 » practically never is carried out for a real atmosphere and exist a number of experimental and theoretical researches devoted to an explanation of these deviations.

One of the largest experts in aerohydrodynamics of an atmosphere, professor of the London university Đ. Scorrer (1980) wrote about application of concept "turbulention " to the real phenomena in an atmosphere:

« First, for this phenomenon there is no uniform universal definition and, secondly, available definitions in a sufficient measure are incompatible among themselves to call us for care in application them at study of some types of movement named turbulention » (is quoted on Russian translation)

At the same time, it is well known, that at the large heights arise and exist the certain time of a zone or layers with raised turbulention , which are probably connected with known in physics of an atmosphere «by jet currents» close troposphere pause . Besides of a turbulention zone in troposphere, where the numbers Raynolds are great enough, are formed between spirals and on a circle of cyclonic formations, before cloudy front, and also bring in distortions to atmospheric optics.

Apparently there are also other reasons of occurrence optical heterogeneity in a real atmosphere.

Thus, simple circuit with inversion near ground advections layer and free atmosphere both rather complex and in detail developed theory of distribution of waves in an isotropic turbulention atmosphere are poorly applicable for a real atmosphere and the researches of optical instability of an atmosphere require{*demand*} other approach. The unique correct conclusion from both models consists that the optical heterogeneity in an atmosphere can completely identify with temperature heterogeneity .

Optical Atmosphere Distortion in a Telescope.

Irrespective of physics of occurrence of optical instability of an atmosphere, the observers collide all with several parameters of atmospheric optical distortions , which are necessary for taking into account in any kind of researches of the trans-atmoshperic images: 1) blinking of the images δ I, which is convenient for measuring in change of intensity of a flow from , 2)σ'' is oscillation of the images, in an angular measure and 3) τ'' is corners of the running images ; the cut on intensity of the dim image has the Gauss structure and consequently the corner $\tau''$is accepted for measuring at a level of half of intensity of a structure. In future (below) we shall use analogous corner t'', calculated for 3-m telescope.

In a small telescope the values blinking and oscillation of the images δI and $\sigma''$are great, and the running corner is insignificant in comparison with the diffraction resolution telescope r ". At increase of an entrance diameter of a telescope d of value of blinking and oscillation of the images δI and σ''decrease, and and the running corner τ'' is increased. At last, in a telescope of the very large diameter the running corner τ''matters only, and blinking and oscillation of the images δI and σ'' very small. All three parameters reflect changes of factor of refraction of beams on the optical heterogeneity . It is easy to understand, that the values δI and σ'' are connected to the relation of the sizes optical heterogeneity with the aperture of a telescope. As the sizes heterogeneity are distributed under the statistical law and differ for various installation sites of telescopes, the law of distribution δI and σ'' depending on the aperture of an entrance pupil of a telescope also is different a little. However, knowing this law for the given item of installation of a telescope, it is possible confidently to predict values of parameters of atmospheric instability for telescopes anyone, including very large diameter.

For elimination of atmospheric optical distortions in a modern adaptive telescope the knowledge of the amplitude-frequency characteristics of δI and σ'',is necessary, besides everything,, and also value of coherency radius r_o in a field of sight of a telescope, inside which does not occur of changes of values δI and σ'' (Shevchenko, 1988). It is possible to receive other values describing optical instability, in particular, parameters of Fried (1966). Having measured values δI and σ'',

IV. Methods and results of measurements of optical nonstability and atmospheric distortions nature.

Methods of optical nonstability study

For the first time at Maidanak the optical method of measurement of amplitude oscillations of the images using 85-mm refractor (Slycky, Princev, 1970) was applied. On complex expedition on Maidanak also were investigated oscillations of the images and blinking in 10-meter focus 200-mm reflector using the photo-electric photometer; with 1970 y. of measurement of quality of the image were carried out with the help of the two-beam device with base 2.4 m (Shevchenko, 1973). All used devices in 1968 were calibrates in Crimean Astrophysical observatory AC USSR from diameter 2,6 and 1,2 meters telescopes and had lenses of diffraction quality. Thus, to 1972 y. representative numbers of observations of quality of the image with these devices were received. Actually in 1972 y. was received exact enough histogram of running corners τ'' of the images in large (D $\approx$3 m) telescope (Shevchenko, 1973). All further researches or confirmed this result, or were received on unsufficient sample or incorrect method.

Novikov at al., (1984) investigated frequency - transfer function of a path an atmosphere a telescope with the help of scanning of the images using photoelectric photometer with slot-hole stop .

The similar method, was used Shevchenko et al., (1988). Further for scanning was used multislot-hole stop, made from cracks of different width for an opportunity of registration of all kinds of optical distortions (δI,σ'',τ''). In a fig. 4 the diagram transparency of a light flow multislot-hole stop is given, on which the parity of width of cracks in seconds of an arch in 7,5-meter focus of 0,6 meter reflector is visible. The similar measurements were carried out during 1983-1989 yy, that has enabled to receive statistically authentic histogram of quality of the im-

age for Maidanak atmosphere (about 3200 measurements for 6 years). In further such philosophy of measurement became possible with CCD- detector.

The analysis of results of regular measurements with various types of the registrars of the image is given in work Artamonov et al. (1987).

In 1992-1999 years B.P.Artamonov and V.N.Dudinov with the employees repeatedly estimated the size of the image in a focal plane of the 1,5 - meter reflector A3T- 12 with the help CCD- imajer.. At last, from R.A. Syuniaev initiative in 1996-1998 years the program of measurements of image quality with the device Differential Image Motion Monitor (DIMM), designed by the ESO specialists and used to estimate the seeing at the La Silla and Paranal Peak Observatories in Chile. The theory DIMM instrument, its design and calibration are detailed in Sarazin and Roddier (1990) was carried out.

All listed above measurements have brought similar results and are compared below.

At the same time, some other methods of measurements have resulted in the worse results. Tokovinin (1984, 1988) applied coherence interferometer, and Shcheglov (1984) used Potoelectric Equipment of Oscillations Atmosphere (FEE). In August, - September 1974 with the help FRAD was obtained histogram of quality of the images on Mt. Maidanak with a maximum about 1. (4 (Shcheglov, 1984). The appreciablly worse quality of the images was received with the modified device FRAD and Illiasov et al. (1992).

It is important to note, that the measurements executed with devices, established on a level of 2-2,5 meters from a ground differed in the worse party from measurements on devices installed at a level 7 - 17 meters.

Observatories are located on Maidanak at two next tops: "«Zapadnaya" and "«Maidanak Peak". Zapadnaya is located in 3,5 kms to west from Maidanak Peak, 150 meters is lower Maidanak Peak and has more flat slopes. Therefore, in opinion of the author near ground layer at top Zapadnaya has the large thickness, than it in a small degree nevertheless has an effect for top Maidanak and on results of measurements of quality of the images. First histograms in 1970-1971 years were obtained at top Maidanak and are corrected to height 17m by results of gradient measurements on a 17-meter mast. Then histogram with slot-hole and multislot-hole photometers also were received at top Maidanak at a level of 7 meters with 0.6-meter reflector. The discussed here results of measurements with DIMM were received at top Zapadnaya at a level of 4 meters and probably it explains small distinction of histograms . The results of measurements of quality of the images received regularly on 1,1 meter telescope on Maidanak and on 1.5- a meter telescope at top Zapadnaya practically do not differ. Both telescopes are installed at a level of 17 meters from a ground.

Methods and results of temperature heterogeneity and atmospheric structures profile research

Measurements of temperature fluctuations and temperature profiles have been carried out since 1970 by wire micro sensors and specially designed registration equipment.

Changes of temperature profile was registered with the accuracy of not worse than 0.01C and temperature fluctuations - with accuracy up to 0.°005C. Regular measurements of temperature profiles and fluctuations were carried out on the top of Maidanak mount with sensors located on a boom of up to 30 m height, with captured balloons at up to 80 m above ground and also with radio probes at altitudes of up to 16 km and a bit worse accuracy of registration of temperature profile.

The Contribution of the Atmosphere Nearground Layer in Optical Distortions.

It is necessary to note, that the considered above simple circuit of optical distortions in an atmosphere, a nearground layer and "free" atmosphere remains by the most simple approximation to real optical - atmospheric conditions.

In cloudless night time a ground or any other spreading surface for some (2 -3) hours after call of the sun begin cool dawn and by morning reach minimal temperature. Already at a level of 2 meters, where temperature of air at meteorological stations, as a rule, is measured, at the night air of a more warmly spreading surface on 3 (- 8 (With. The vector of speed of a wind always has a vertical component and short-term changes on size (pulsation). A vertical component and the pulsations of a vector of speed of a wind also form of temperature (optical) heterogeneity of the large amplitude in a nearground layer Umarov (1984).

The thickness of a nearground layer can reach on plain of several tens and even of hundreds meters. It can well be seen at measurements temperature heterohenous by lidar (acoustic probe) (Kallistratova and Karyukin (1984). However above the isolated tops the thickness of a nearground layer is much less and already at a level 6 - 10 ì above a ground it is possible to observe inversion of temperature in night time. The small contribution of a

nearground layer above the isolated tops in mountains and affinity of a free atmosphere allow to hope for much smaller optical distortions and more favorable conditions for installation of a telescope.

During forwarding measurements in various items ,(Shevchenko 1972) the elementary test for properties of optical instability in certain to item was determined. As the optical instability in high layers of an atmosphere poorly depends on a choice of a place in extensive enough region, first of all it is necessary to search for such items, where the contribution of a nearground layer is minimal. The experience has shown, that thickness of a nearground layer is easily defined on daily amplitude of temperature of air during steady cloudless weather. In a fig. 5 the results of simultaneous measurements of a daily course of temperature in area of city Kitab , valley of the river Kashka-Daria and situated at 70 km to North - West from Maidanak on the 650 m level on sea. and at top of a mountain Maidanak at a level of 2 meters in a standard meteorological box and at a level 12 m on the top of a mountain Maidanak in the same conditions of June 12, 1973 are given. The essential reduction of daily amplitude of temperature at a level 12 m , 2.8 C° testifies to the small contribution of a nearground layer and affinity of a free atmosphere (Figure 5).

These measurements were mainly aimed to understanding of the nature of atmospheric optical instability in the region of Maidanak mount. Finally we came to the conclusion that the height of near ground inversion layer on the top does not exceed 20 m and that in the period of stable anticyclones, when signs of movement of atmospheric fronts are not present at heights up to 16 km over sea level, high layers of atmosphere over Maidanak region are characterized by uncial low movement speed (less than 10 m/s during a few dozens of hours . In this time period all the atmosphere introduces minimum distortion in the wavefront and exactly this atmosphere can be considered as a "free atmosphere" in geophysical sense. The most attention shall be paid to suppression of heterogeneities appearing due to advection in the near ground layer (inverted with its temperature in the night time). On the Maidanak Peak near ground inversion layer has a thickness near 10 -20 m only. The typical profile of near ground air temperature , as a samples are given on Fig.6. Our studies aimed to the improvement of design of astronomical tower are connected exactly with this situation.

In the time period when atmospheric fronts reach Maidanak region, image quality is getting worse. Depending on movement intensity and front temperature, optical distortions are increasing. The worse situation appears right before coming of wide fronts carrying thick cloud layer. However, in this conditions, measures taken for suppression of local optical fluctuations in the near ground layer, are not absolutely useless.

At top Zapadnaya the daily amplitude of temperature of air is little bit more 7° C with, as gives the basis to assert about the a little bit greater thickness of a night inversion layer in comparison with Maidanark Peak.
Such were our first tests in astronomical items at a choice of observatories at Central Asia Mountains, in Southern Siberia and on Far East of Russia, and also in Iraq, Algeria and other areas.

Atmosphere structure profiles

On Figure 7 average from 63 measurements with atmosphere radio explore balloons the temperature atmospheric structure on Maidanak Peak is compared to a standard atmospheric structure (Allen, 1973). The difference is essential at heights more than 10 km, where «atmospheric jet currents » with speeds of a wind more 20m/ sec are observed more often. These layers of air in jet currents are be turbulentionly also.
The large interest is represented also results of measurements of a structure of a wind speed vector down to heights 12 km . These measurement were carried out in night clear time using a balloon with a light source. The angular measurements at the identical moments of time using two exact theodolites, taking place on precisely fixed distance from each other, enable to receive an exact structure of a wind speed vector.
The large surprise for the observers became absence of the large values (V > 12 m/sec) wind speed vector at heights 8 - 12 km in epoch of a stable anticyclone.

In the beginning 70 years of optical heterogeneity were precisely identified with temperature atmospheric heterogeneous . Any fluctuations of humidity, pressure, quantity of aerosols etc. do not result in such changes of factor of refraction of air, as temperature heterogeneity.

At the same time, even at distortions of a temperature structure fluctuations of a of wind speed vector , and first of all by its vertical component, result in occurrence temperature heterogeneity .

By special measurements was exactly shown, that fluctuation of wind speed vector form of optical heterogeneity in atmosphere (Umarov, 1984)

The temperature structure of a night nearground layer after an establishment of stable inversion of temperature is shown on Figure. in the beginning of a summer and in the autumn -winter period. The results are obtained using

gradient measurements on 30- meter masts and the captive balloon at heights up to 60 meters above a level of a ground on Maidanak Peak.

The direct results of measurements fluctuations of temperature in the inversion layer at various levels above Maidanak Peak with without inertial temperature gauges suspended at different levels on 30- meter masts are given as histograms on Figure 8.

Above we have noted (Shevchenko, 1988) the negative attitude to the theory of «isotropic turbulention atmosphere» of Tatarsky (1967). We only formally defined values «of structural functions» Ct^2 and Cn^2.

However other authors (Gurianov et al., 1984, Tokovinin, 1984 et al.) repeatedly were engaged in definition and analysis of structural atmospheric functions on Maidanak Peak and Zapadnaya.

Results of measurements of quality of the image on the Maidanak

The histograms of distribution of corners t" of quality of the atmospheric image at level 50 % (FW t") from a maximum of intensity of the image for 3-m diameter of telescope are compared in a fig. 9. Each point by separate histogram represents quantity of the images in percentage less given on an axis X. The curves 1-2, received on Maidanak Peak, on the most representative numbers of supervision.

The curve 1 was obtained for 18 years, mostly by method of photo-electric sections, contains about 9000 measurements. About 2000 measurements is submitted in histogram 2, obtained in 1970-1972 yy (Shevchenko, 1973) on the first complex expedition. Similar quantity of measurements make histograms, received on top Zapadnaya by Novikov (1987) with his Photoelectric Instrument for Atmosphere oscillations measurement (FRAD), (curve 5), by Artamonov et al. (1987) with Double Beam Instrument (curve 7) and curve 4 (Il'yasov, Baizhaminov, Sarazin et al., 1999) using DIMM. Much smaller numbers of observations are obtained on the Zapadnaya top by Il'yasov et al. (1992) using Tokovinin's Coherency Interferometer (curve 6, 28 nights) and using Shcheglov's Photoelectric Instrument (curve 9, 34 night). We compare it with others histograms, as these data are analyzed in last work (Il'yasov, Baizhaminov, Sarazin et al., 1999). Exception make 2 curve, received in identical seasons of steady weather with small number of measurements.. The curve 3 (about 100 measurements for 25 night in August - September 1969 y., for the first time is received by forwarding group of Astronomical Institute of an Academy of Sciences Uzbek SSR) at top of a mountain Maidanak under a methodical management Shevchenko V.S. and is published in 1970 year. The curve 8 was obtained with Shcheglov Photoelectric Instrument (about 1000 measurements in August - September, 1974). These curves give extreme best (curve 3) and worst results (curve 8). The results of 25-year's observations of the atmospheric image quality have shown, what exactly in August September the best images on the average are annually observed. Therefore curve 8 apparently is erroneous because of lacks Shcheglov's Photoelectric Instrument, which were discussed at a conference of 1981 in Abastumani (Shcheglov, 1984). Same it is possible to suspect, analyzing a curve 8, received with the similar device. As the participants of a conference repeatedly marked, the device has the limited sensitivity in the field of the images t "< 0 ".5 and is poorly sensitive to the images t "> 2 ".

In a fig. 10 are compared histograms of quality of the atmospheric image appropriate by a curve 1,2 and 4 on a fig. 9.

Some results of comparison the following:

1).All methods of a rating atmosphericoptical distortions, calibrated on the large telescopes, except for mentioned above give similar results. The average value makes corners of atmospheric distortions 0 ".6 - 0 ".7.

2).Greatest distinctions histogram, obtained by different methods are observed in the field of small corners (t "< 0 ".4) and worst images (t "> 1 ".2). We believe, that concerns to a great extent to tool regular errors. The nature of atmospheric optical distortions carries a statistical property and at the large enough number of measurements should have an identical kind for all types of tool measurements, (for example to correspond to distribution Puasson). In the field of the best images, any device has restriction of sensitivity, as the considered above curve 8 in a fig. 9. The distinction in the field of the worst images, besides is connected to sample of an interval of measurements. At unstable clear weather, percent of the worst images is increased. Nevertheless all objective methods show, that 80 % of the images on Maidanak and Zapadnaya tops are better 1".

3). At measurements at a level of 2-3 meters from a ground near ground the layer brings in the appreciable contribution. So in particular, on a crest Maidanak Peak two identical 60-cm telescopes are installed in 20 meters from each other, but one at a level 3m from a ground, and another at a level 8m. Within many years the observers marked, that the quality of the atmospheric image on the top telescope in 1.3 - 1.5 times is better, than on bottom. At top Zapadnaya at levels 3 - 7 meters are observed on the average some deterioration as the images in comparison with Maidanak Peak. However telescopes installed on a level 17m above a ground as on Maidanak Peak as well as

Zapadnaya top show practically identical images. This level of installation of telescopes guarantees the weak contribution of near ground layer.

4). On all astroclimatic parameters and is especial on quality of the atmospheric image, Maidanak Peak is one of best observatory in the world.

The best demonstration it is the direct images of natural and artificial space objects obtaineded on telescopes with the high tool resolution on Maidanak Peak and Zapadnaya.

Some examples of the images with the high resolution received on Maidanak.

In 1981 on Maidanak Peak 2 telescopes with the aperture 1,1 m with the tool sanction 0.3 - 0.35 were installed The telescope diameter 1,5 m with the same tool resolution was installed in 1992 year on the Zapadnaya top.
At installation of telescopes in both cases the special designs astro-domes were applied which as much as possible reduced influence near ground layer, and also were equipped with ventilating high-power installations for fast alignment of temperature conditions inside towers and outside. The results of research of influence of towers of special designs on Maidanak are discussed in works Umarov (1984b) and Novikov and Ovchinnikov (1984).
We shall result all some examples of the direct images received on these telescopes.

One of first images was made on the 1,5-m reflector by Dudidinov's groups was the Mars images from December 17,1992,20h13m UT. Apparent angular diameter of Mars is 14"3. Cenral meridian longitude is 59 deg.. Fragments of images less than 0"5 are visible. Ordinary photo.(fig 11)

On the Fig. 12 is given image of Gravitational lens "Einshtein Crux", in QSO 2237+0305 quasar direction ,that was obtained on the 1,5m reflector . The average angular distance between three images splitting of far quasar is 2"2. It is direct image at 300 sec. exposition, without any digital processing. Image was made on the amateur CCD imager "Pictor 416 XT " by Boris Artamonov jointly German and Ukrainian astronomers in October 31, 1995. Atmosphere resolution on this image is less than 0."35. The size of 1 picsel is 0."17.

On the fig .13 is given the image of Russian Space station "Mir" unated with USA Space Shuttle "Atlantic" in August 1995 on the 110-cm reflector was made by V.Samonov's groop on the Maidanak Peak. Direct photo on the spesial emulsion. The angular size of Mir+ Atlantic is 14". Covers of Shuttle chassis are visible clear.

The series of the ERS satellite images was obtained on the 1,1m reflector be V.P.Epifanov and S .Krainov and are given on the fig 14. Each photo has size 4"x 4". Satellite details less than 0.3 are visible.

In 1997 on 1,1 m a telescope the adaptive system on a flat diagonal mirror was tested and first were received pure diffraction images of bright stars. However regular supervision with adaptive optics on Maidanak Peak till now were not carried out.

The above mentioned examples show opportunities of reception of the images of higher resolution with adaptive systems on Maidanak Peak.

Conclution

We have considered results of researches of Mt. Maidanak sky testing from 1969 to 1999 years. Not all results of researches of atmospheric optics were analysed. We did not state the point of view on a nature of atmospheric handicapes of other researchers, since the purposes did not pursue to subject to their critical analysis.

In 1989-1991 years the author, following on a way ESO, has undertaken new forwarding measurements of atmospheric optics, were based on the concept of an origin of atmosphere optical distortions, which is stated in the given review. In result, in 100 km to South from Maidanak Peak was founded a top for new astrophysical observatory Kugitang Tau Peak. The quality of the image at top Kugitang Tau Peak approximately in 1.3 -1.5 times is better, than on Maidanak observatory. Besides at this top on 10 % there is more clear time with other things being equal. And this top definitely would make a competition by best astronomical observatory of the world. In the given work, unfortunately there is no place for performance of results of research Kugitang Tau Peak.

In 1975 on Maidanak observatory the regular astronomical supervision have begun. By 1990 became abundantly clear, that Maidanak observatory on quality of atmospheric optics is by best observatoryin territory former USSR and one of observatory of the world.

Specially for Maidanak observatory the industry USSR made high-quality optics for 1,1 m and 1,5 m telescopes. The supervision on these telescopes within many years have confirmed, that on these telescopes even without adaptive optical devices it is possible regularly to receive the images of space objects with the high sanctions. In particular, in some cases, it was possible to receive results comparable to results, received on Space Hubble Telescope. In particular in 1992 the first maps of a small planet Pallada were received, which diameter made only 0 "5.

After disintegration USSR in 1993 Maidanak observatory has passed in conducting an Academy of sciences of Republic of Uzbekistan. By efforts of Astronomical Institute of Uzbekistan, and also astronomers of Russia, the

Ukraines and Lithuania on the basic telescopes observatory proceed astronomical observations and Maidanak observatory participates in many international programs, bringing unique results. We thank all our foreign partners from USA, first of all George Herbig and William Herbst, of France (is especial Eric Fossat), Germany, Holland, Taiwan and other countries, which have helped to receive to the astronomers of Uzbekistan the foreign grants for support of the observant programs.

We also would like to thank the astronomers who have brought in the greatest contribution to researches of an astroclimate on Maidanak Peak and Zapadnaya: B. P. Arnamonov, V. N. Dudinov, S. B. Novikov, A. A. Ovchinnikov, A. A. Tokovinin, M. Sarazin, V. D. Shargorodsky, P. V. Shcheglov et al..

REFERENCES

Allen C.W.,1973, Astrophysical Quantities, The Athlone Press. London.

Artamonov B.P., Novikov S.B., Ovchinnikov A.A., Methody povysheniya effektivnosti opticheskikh teleskopov (Methods for Increasing the Efficiency of Optical Telescopes), Gladyshev S.A., Ed., Moscow, Mosc. State Univers.,1987,P 16

Berdnikov L.N. and Shevchenko V.S.1988, in «Atmosphernaya nestabil'nost' I adaptivnyi telescop» (Atmosphere nonstability and Adaptive Telescope)., Kurmaeva A. Kh. And Shevchenko V.S. Edit., Leningrad, Nauka, P 131

Feinman R. et al.., 1966, Feinman's Lectures for Physics (in Russian Translation), MIR, Moscow.

Fried D. L. // J. Opt. Soc. Amer., 1966. V 56. P 1372

Gurianov A.A., Han Yu. V. Shcheglov P.V.,1984, «Astroklimat I effectivnost' telescopov» (Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh. Edit., Leningrad, Nauka, P

Illiasov S.P.,Baizhumanov A.K.,Sarazin M., et al. 1999 , Pis'ma v Astronomicheskii Zhurnal (Astronomy Let ters.), V 25, P 156.

Illiasov S.P., Kurtuev A.S., Tokovinin A.A. and Shcheglov P.V.,1992, Preprint Gos. Astron. Shternberg Institute .MSU,N 21,P 3

Kallistratova and Karyukin (1984 Astroklimat I effectivnost' telescopov (Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh. Edit., Leningrad, Nauka, P 55

Novikov et.al.,1984, «Astroklimat I effectivnost' telescopov» (Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh. Edit., Leningrad, Nauka, P 73

Sarazin M. and Roddier F., Astron. Astrophys., 1990, V 227,P 297

Scorrer R. (1980) .,Aerohydrodynamic of environment ., (in Russian Translation), MIR, Moscow.

Shevchenko V.S., 1972 ,Molodye zvevdnye Komplexy. Astroklimat. (Young Stellar Formations. Astroklimate.) FAN, Tashkent, P 43.

Shevchenko V.S., 1973,Astron. Zh., V68,P 632

Shevchenko V.S, 1984a, «Astroklimat I effectivnost' telescopov»(Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh. Edit., Leningrad, Nauka, P 5

Shevchenko V.S ,1984 b, «Astroklimat I effectivnost' telescopov» (Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh. Edit., Leningrad, Nauka, P 93

Shevchenko V.S.1988, in «Atmosphernaya nestabil'nost' I adaptivnyi telescop» (Atmosphere nonstability and Adaptive Telescope)., Kurmaeva A. Kh. And Shevchenko V.S. Edit., Leningrad, Nauka, P 3

Shevchenko V.S. et al.1988, in «Atmosphernaya nestabil'nost' I adaptivnyi telescop» (Atmosphere nonstability and Adaptive Telescope)., Kurmaeva A. Kh. And Shevchenko V.S. Edit., Leningrad, Nauka, P 83

Shcheglov P.V.,1984, «Astroklimat I effectivnost' telescopov» (Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh. Edit., Leningrad, Nauka, P 126

Slutckii V.E. and Princev A., 1970,Astronomical Circular ,N 576. P 3.

Tokovinin A. A. ,1984, «Astroklimat I effectivnost' telescopov» (Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh. Edit., Leningrad, Nauka, P 116

Tatarsky V.I., «Distribution of waves in an turbulentionly atmosphere. Moscow. "«Science" .1967

Umarov v.f. ,1984, Astroklimat I effectivnost' telescopov (Astroklimat and Telescopes Efficiency), Shevchenko V.S and Kurmaeva A. Kh., Leningrad, Nauka, P 93

Zheleznyakova A.I., 1984, Astroklimat I effectivnost' telescopov (Astroklimat and Telescopes Efficiency), V.S and Kurmaeva A. Kh., Leningrad, Nauka, P 55

FIGURES CAPTION

Fig. 1a. Spectral factor of extinction vs. seasons. 1 - May- August; 2 - October-March. Shaded part corresponds to the pure molecular attenuation at the height 2750 m.
Fig. 1.b. Averaged values of extinction spectral factor on Maidanak mount, after numerical accounting of molecular dissipation in different periods. 1 - July-August 1978, 2 - September-March 1980-1981, 3 - September-March 1977-1978, 4 - 3-year period 1975-1977 (Zheleznyakova, 1984)

Fig. 2a Calibration curve obtained from aerological data for water vapor absorption bands 720 and 820 nm
Fig. 2b Histogram of distribution of average monthly reduced thickness of water vapor in atmosphere column during a year on Maidanak.

Fig.3. A sample of sky background photoelectric measurement result from 29 September 1975 year on Maidanak Peak (Shevchenko,1984b). Dots is place of light contamination measurements.

Fig.4. The transparency profile of multi -slit forward optical element of multi -slit Photometer (MSP). It was a main instrument for atmosphere optical distortion on the 0.6-m reflector ,installed on 8 meter high under ground on the Maidanak Peak in 1982- 1992 years term.

Fig.5.Daily course and amplitude of air temperature on the Maidanak Peak on the different level and on the Kitab station (typical point on the flat country).

Fig.6. A typical night inversion air temperature profiles on th Maidanak Pear in the stable anticyclon and long clear sky term.

Fig.7. The comparison average profile for atmosphere temperature under Maidanak Peak (average from 63 profiles measurements) and standard atmosphere profile.

Fig.8.Comparison of the histogram distribution of temperature heterogeneity on the different level on the Maidanak Peak.

Fig.9.Image quality measurement main results by different methods and in different terms from 1969 to 1999 years.

Fig.10.Comparison of the three main histogram of image quality corners t" distributions.

Fig 11.One of first images was made on the 1,5-m reflector by Dudidinov's groups. Mars images from December 17,1992,20h13m UT. Apparent angular diameter of Mars is 14"3. Cenral meridian longitude is 59 deg.. Fragments of images less than 0"5 are visible. Ordinary photo.

Fig 12.Gravitational lens "Einshtein Crux", in QSO 2237+0305 quasar direction. The average angular distance between three images splitting of far quasar is 2"2. It is direct image at 300 sec. exposition, without any digital processing. One picsel size is 0"17. Image was made on the amateur CCD imager "Pictor 416" by Boris Artamonov jointly German and Ukrainian astronomers in October 31, 1995.

Fig 13.The image of Russian Space station "Mir" unated with USA Space Shuttle "Atlantic" in August 1995 on the 1,1-m reflector was made by V.Samonov's group. Direct photo on the special emulsion. The angular size of Mir + Atlantic is 14". Covers of Shuttle chassis are visible clear.

Fig.14. ERS satellite photo-images series was made by V.P. Epifanov and S. Krainov at 1,1-m reflector Maidanak Peak from 18 July 1995 years. Size each pictures is 4" x 4". Computer model of satellite ERS situated are given below.

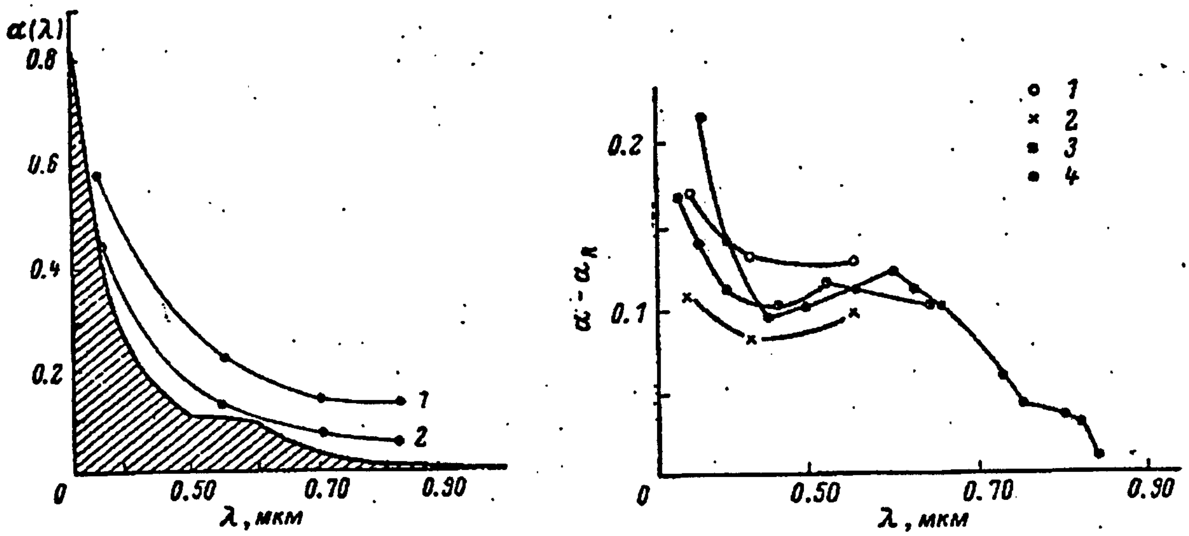


Figure 1

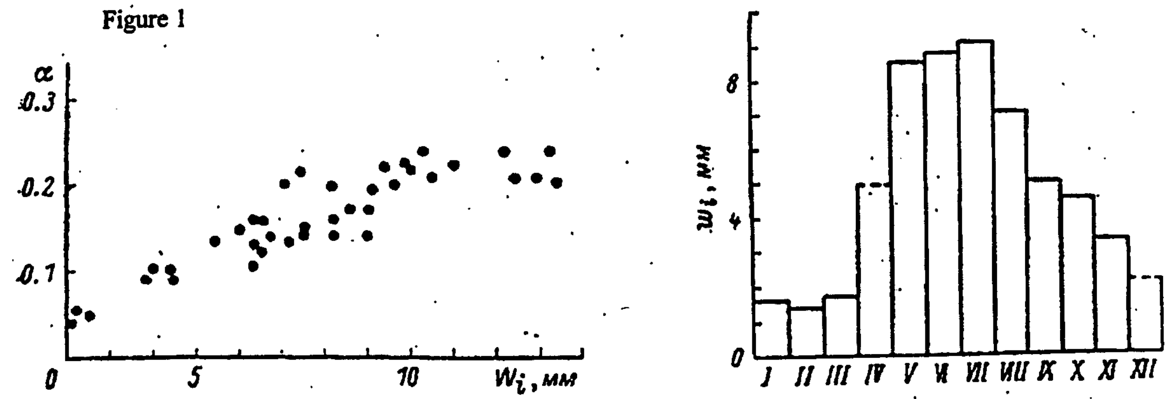


Figure 2

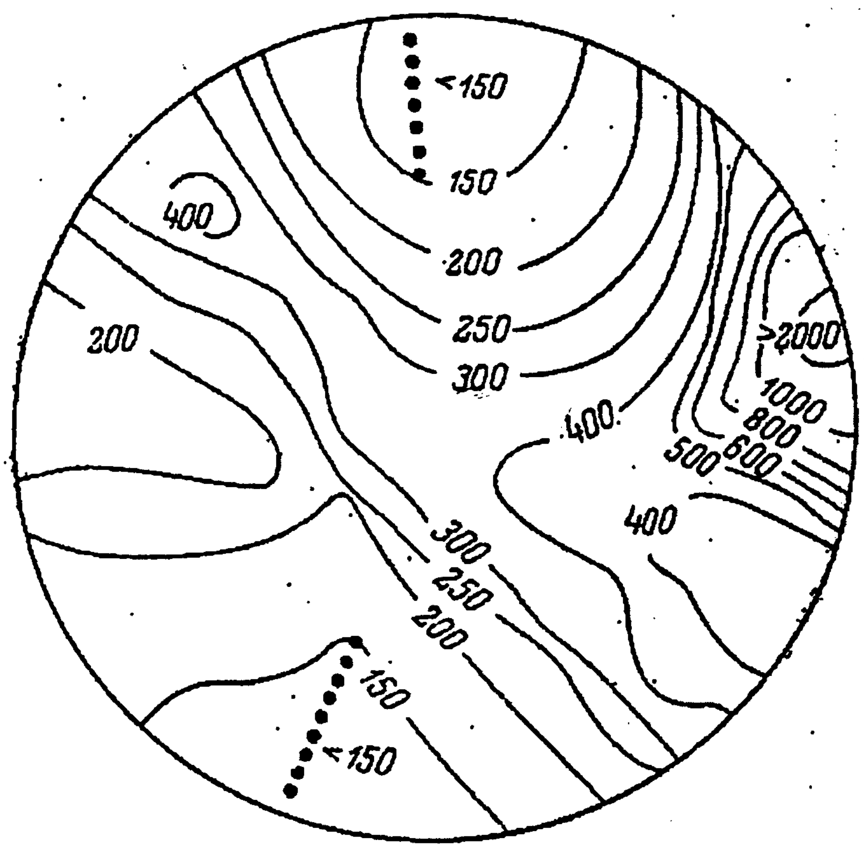


Figure 3.

fig_4a.pcx

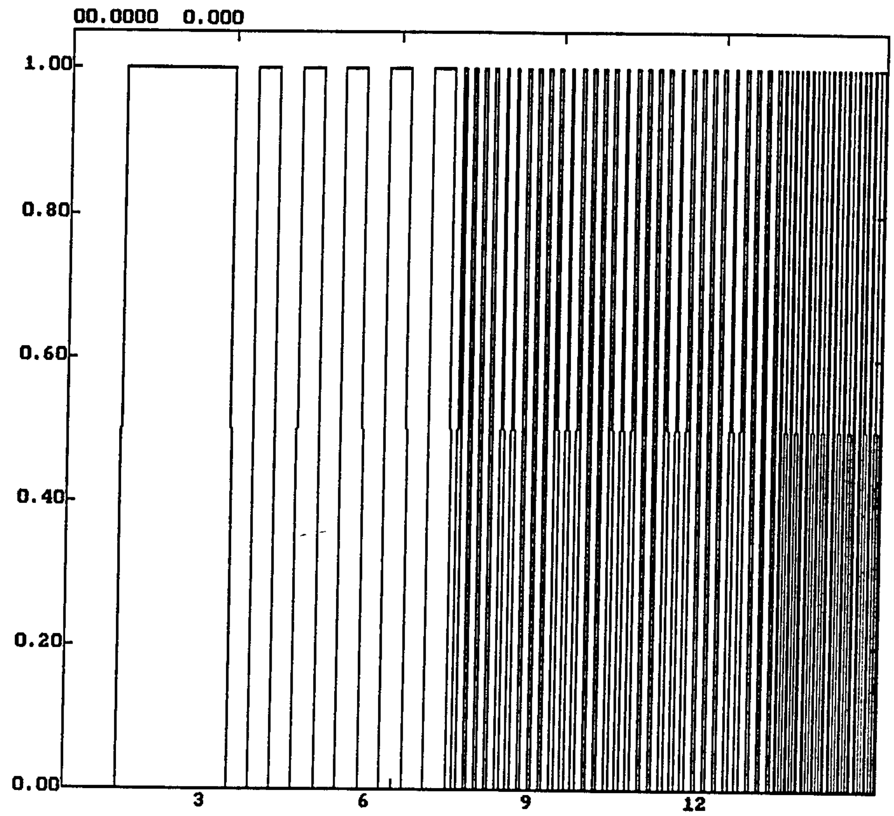
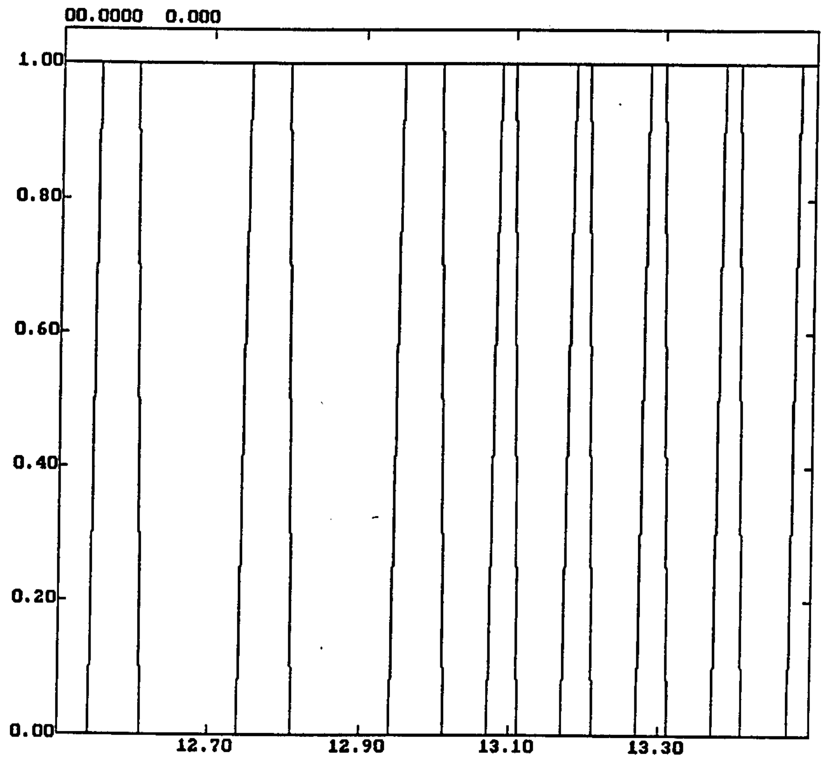
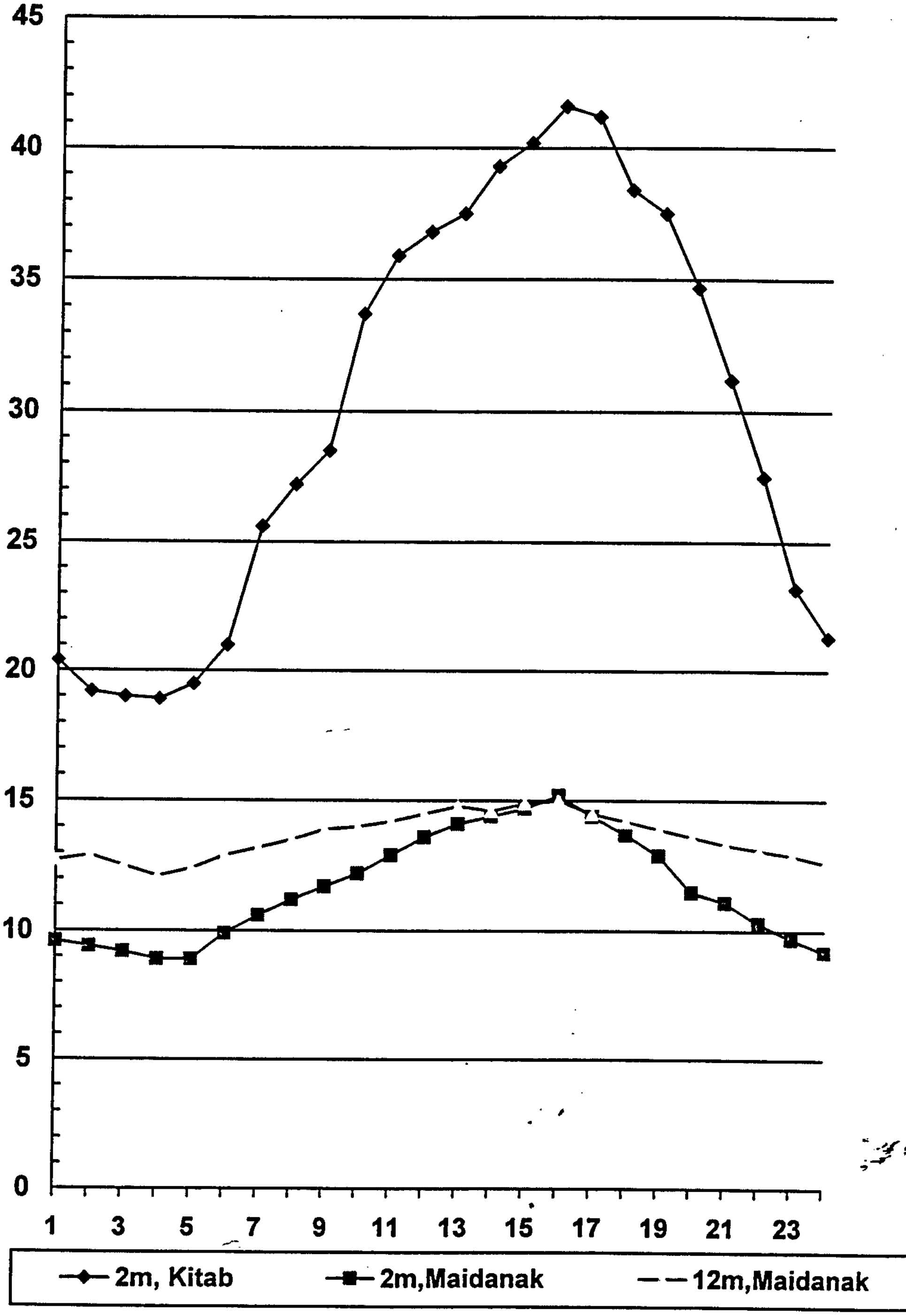
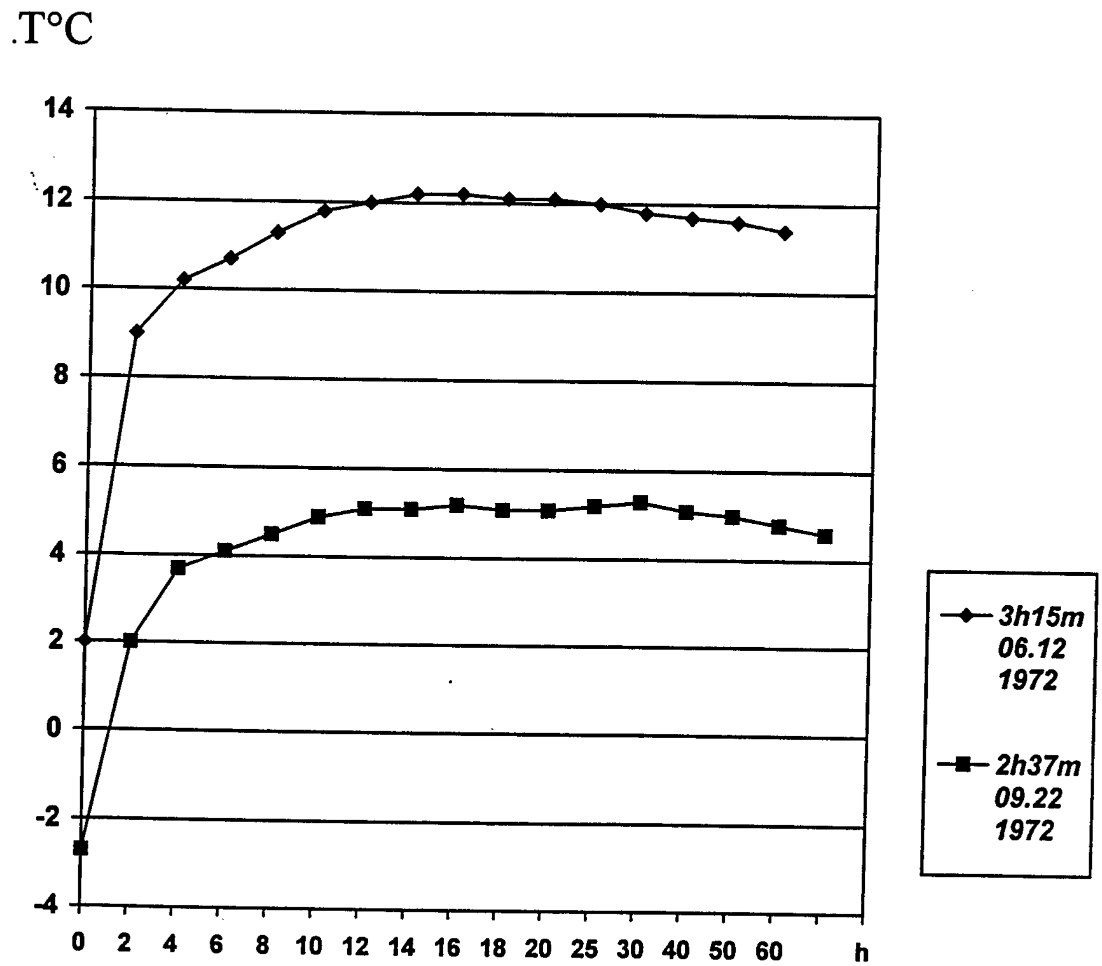


fig_4b.pcx

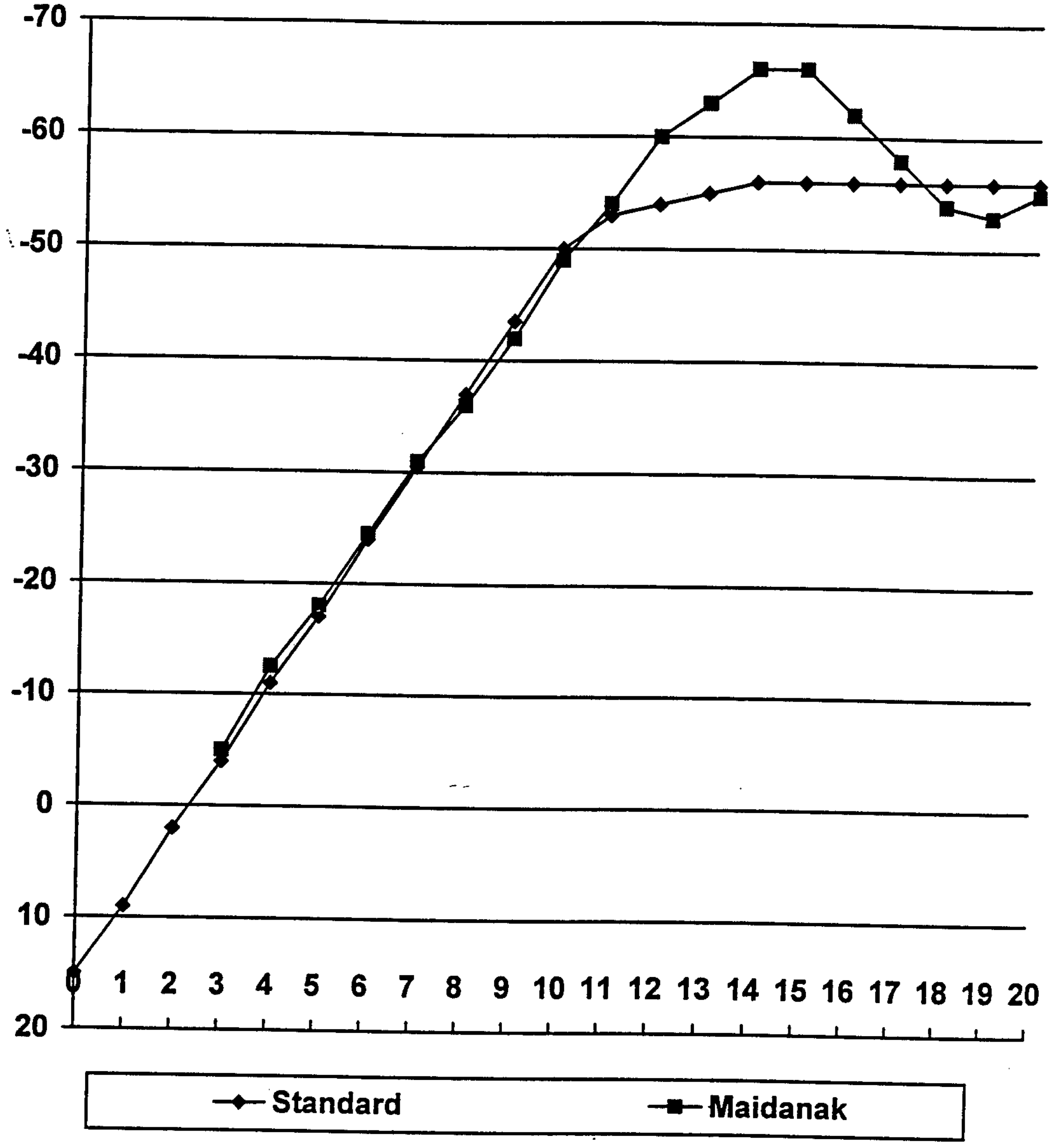




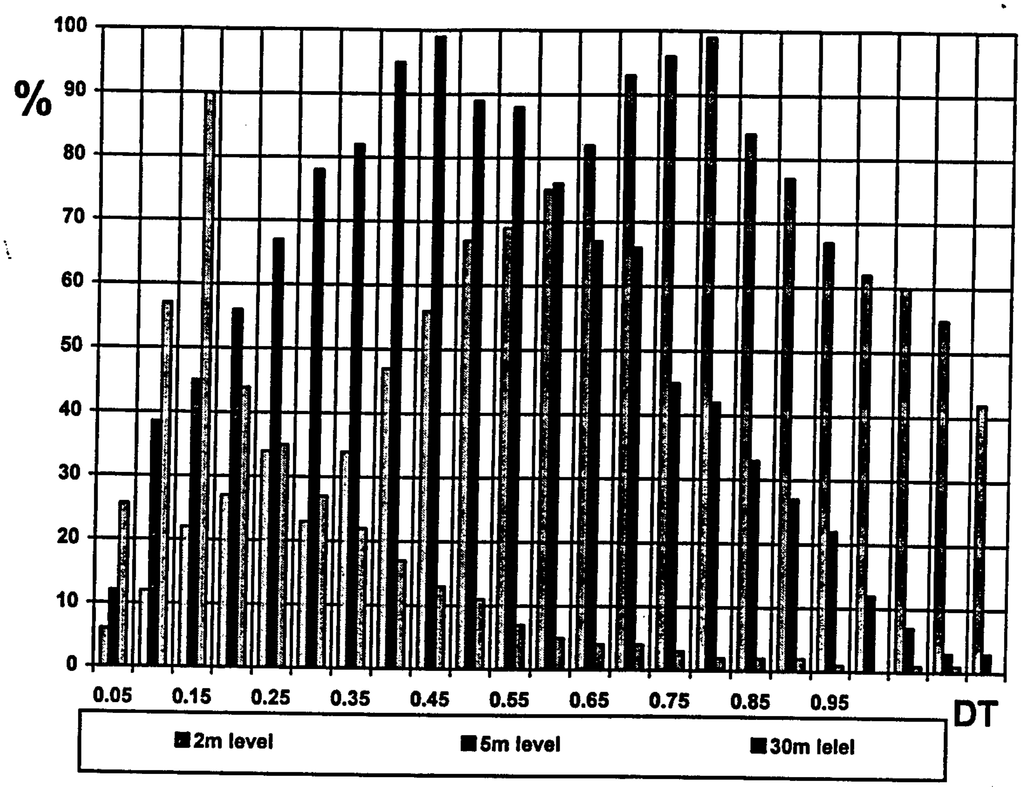
45
40
35
30
25
20
15
10
5
0
1
3
5
7
9
11
13
15
17
19
21
23
2m, Kitab
2m,Maidanak
12m,Maidanak



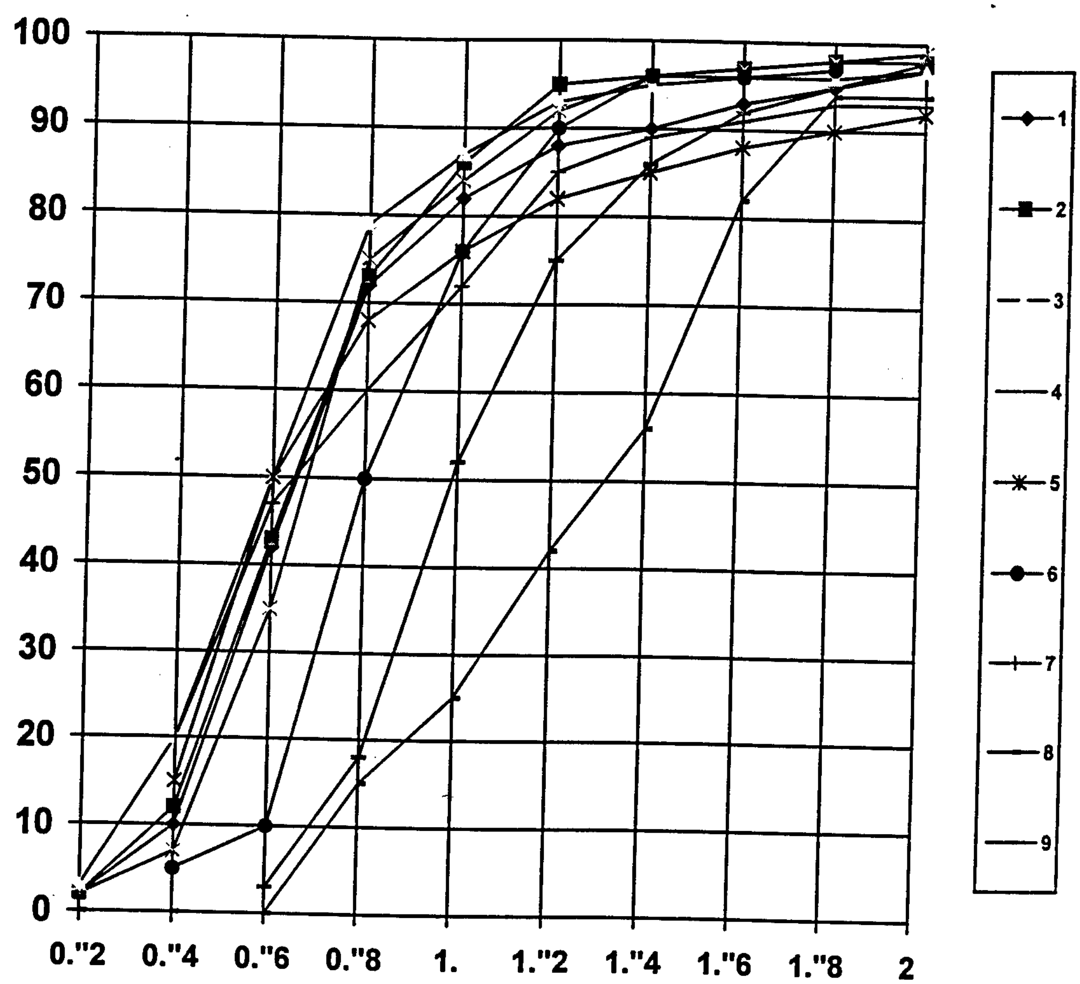
.T°C
14
12
10
8
6
4
2
0
-2
-4
0 2 4 6 8 10 12 14 16 18 20 25 30 40 50 60
h
3h15m 06.12 1972
2h37m 09.22 1972



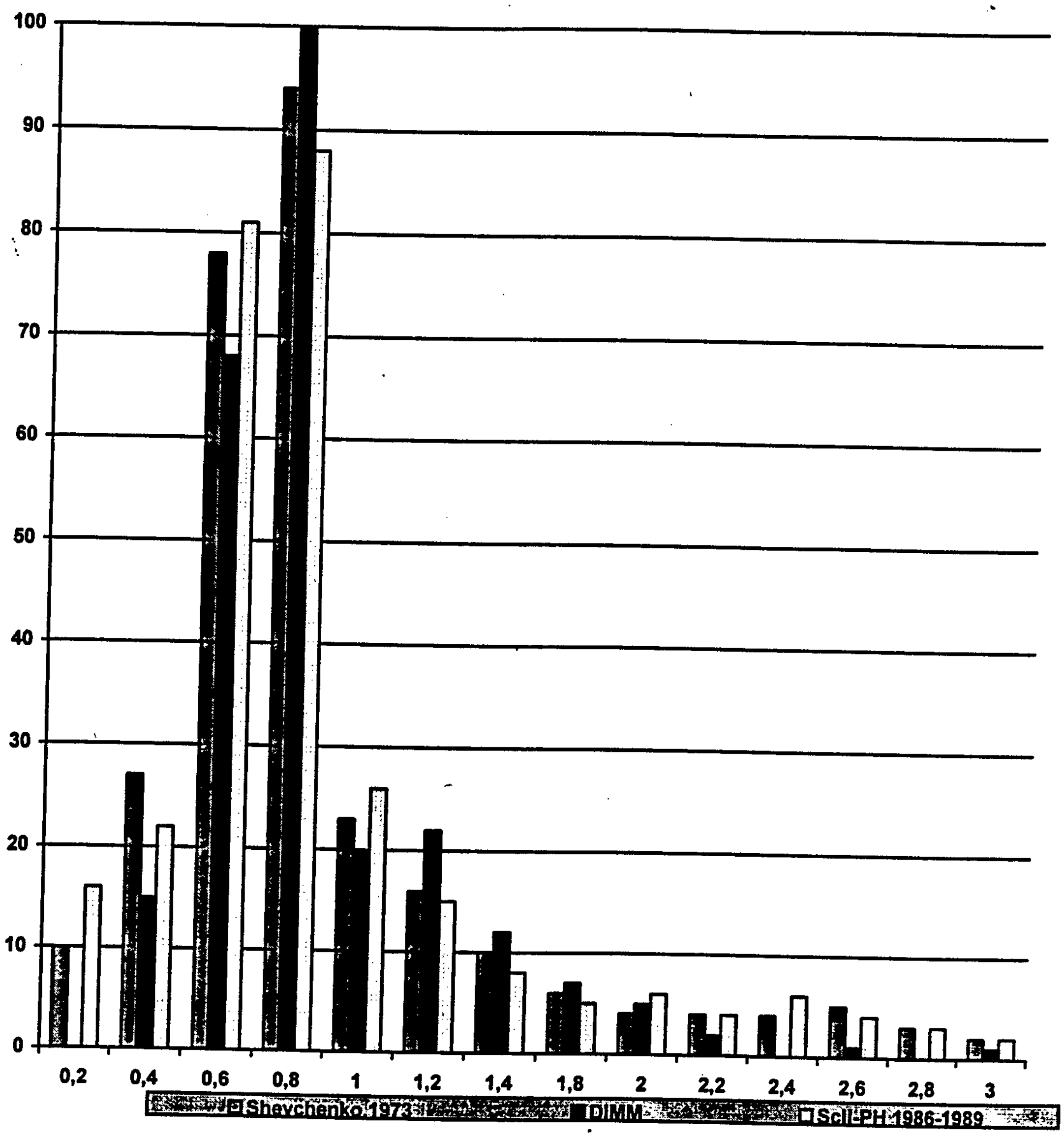
-70
-60
-50
-40
-30
-20
-10
0
10
20
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Standard
Maidanak



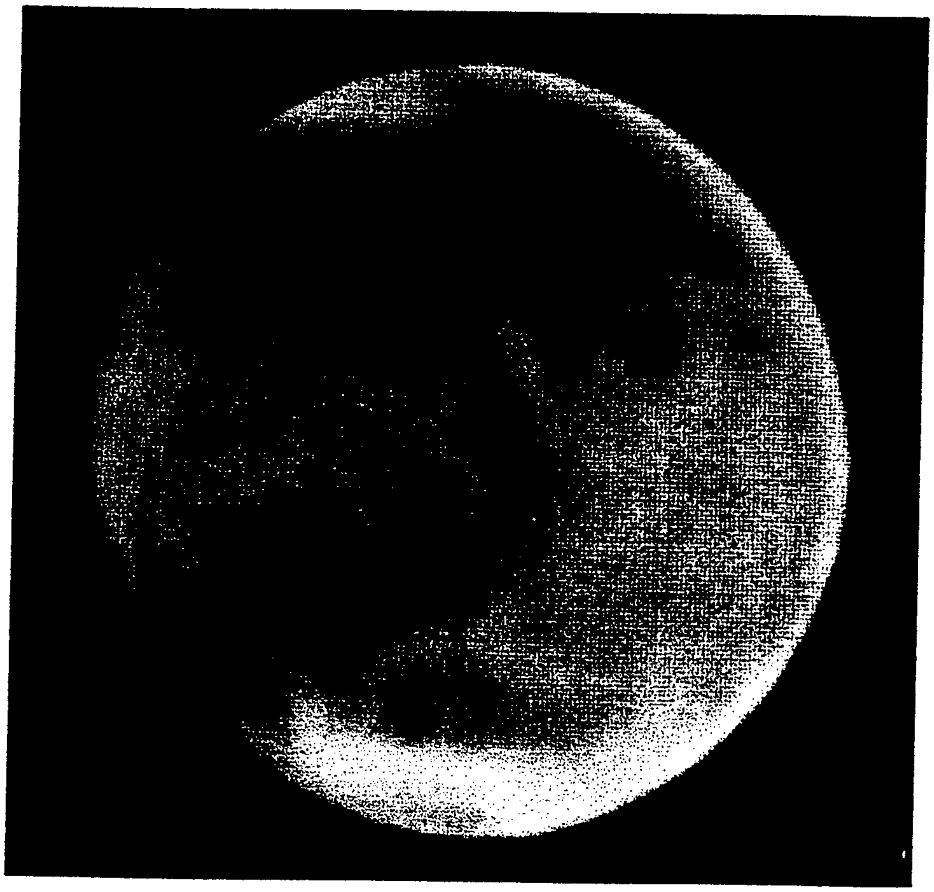
%
100
90
80
70
60
50
40
30
20
10
0
0.05
0.15
0.25
0.35
0.45
0.55
0.65
0.75
0.85
0.95
DT
2m level
5m level
30m lelel



1. Shevchenko, Average of all measurements 1970- 1989 years on the Maidanak Peak
2. Shevchenko (1973), ,a few methods , Maidanak Peak
3. Sluzkii & Prinzev (1970), Maidanak Peak
4. Il'yasov, Baizhumanov , Sarazin et al.(DIMM), (1999),Zapadnaya
5. Novikov,(1987), (FRAD)Zapadnaya
6. Il'asov et al.(1992, (Torovinin's Coherent Interferometer), Zapadnaya.
7. Artamonov et al.(1987), DBI ,Zapadnaya
8. Shcheglov (1984), (Shcheglov's Photoelectric Instrument), Maidanak Peak
9. Il'asov et al.(1992, (Shcheglov's Photoelectric Instrument), Zapadnaya


100
90
80
70
60
50
40
30
20
10
0
0,2
0,4
0,6
0,8
1
1,2
1,4
1,8
2
2,2
2,4
2,6
2,8
3
Shevchenko 1973
DIMM
Scll-PH 1986-1989

Mdnfig11.jpg



Mdnfig12.jpg